APPARATUS AND METHOD FOR CYCLIC ADJUSTMENT OF A SUPPORTING ELEMENT IN A SEAT

Cross-Reference to Related Applications

None.

Statement Regarding Federally Sponsored Research or Development.

Not Applicable.

Background of the Invention

Field of the Invention

The present invention relates to an apparatus and method for reducing the symptoms and occurrences of muscle fatigue in a seat occupant and, more particularly, to an apparatus and method for adjusting the position of a supporting element in a seat such as a lumbar support.

Related Art

Persons who have to remain seated for relatively long periods of time develop symptoms of fatigue and disturbed circulation, which as a whole have a negative effect on their well-being, concentration, and performance. In the case of relatively long automobile trips in particular, this is undesirable in terms of road safety. In fact it is recommended that people take rest breaks and engage in physical exercises every now and then, but this cannot always be done.

Contributing factors to muscle fatigue in sedentary individuals include decreased blood flow and oxygen, individual muscle fiber fatigue, vertebral disk compression and, possibly the build-up of lactic acid within the muscle fibers and surrounding tissues. Additionally, an individual's posture gradually slumps during prolonged periods of sitting thereby changing the

curvature of the person's spine. The prior art has recognized that some relief from back pain is provided by manipulating the curvature of a seat occupant's spine. Recent ergonomic studies attribute these problems to static muscle activity, however, which is not relieved by a static lumbar support, even with a customizable curvature. In this regard, the present invention provides for repeated movement of the spinal area and muscle tissues in small increments to create a pumping action that increases blood circulation through the muscle fibers, creates passive movement and prevents lactic acid build-up. The periodic displacement of the spine and muscle tissues by small movements of a lumbar supporting element have been found to be particularly effective at reducing muscle fatigue during prolonged periods of sitting.

As indicated above, there are many seats familiar to the art that attempt to address the occurrence of, and symptoms related to, muscle fatigue and disturbed circulation. More particularly, with respect to motor-vehicle seats, massaging elements, hand-driven or motor-driven arching elements adjustable in height and degree of curvature have been found to be popular with seat occupants for improving posture and comfort. More particularly, the vibrating or massaging mechanisms known in the art directed to relieving the muscle fatigue perceived by the seat occupant also increase blood flow, passively move the spine and mitigate the lactic acid build up. Whether such motion is perceptible to the seat occupant or not depends on many variables. Early studies, such as those cited in U.S. Patent numbers 5,816,653 and 6,007,151 indicated that movement of 6 to 10 millimeters may not be perceptible. More recent studies indicate that many people can feel a movement of such magnitude, although a 12 millimeter move is more readily perceived. More importantly, recent studies reveal that the motion is beneficial whether perceived or not, and that the benefits remain if the motion is a desired comfortable massaging motion.

The adjustable arching supporting elements known in the art are generally mechanical or motor driven apparatuses positionable according to the preference of the seat occupant. Such manually actuated systems fail to provide the repetitive and specifically controlled positioning features of the present invention that have been found to be particularly effective at reducing or eliminating lactic acid build-up and muscle fatigue. Prior lumbar support cycling devices such as those disclosed in U.S. Patent number 5,816,653 and U.S. Patent number 6,007,151 necessarily rely on incremental steps understood to be imperceptible. There remains a need for combining the benefits of passive movement with the desirable perceptible movement in an economical, robust device.

Proprietary electromyolography ergonomic studies reveal an advantageous decrease in muscle activity with the combined massage effect and cyclic passive motion afforded by a cyclic flexion of variable curvature ergonomic support devices such as a lumbar supports, especially as applied to traction actuated, archable lumbar supports.

SUMMARY OF THE INVENTION

In view of the above, the present invention provides an apparatus and method for adjusting the position of a supporting element within a seat according to a specific cycle to relieve muscle fatigue of the seat occupant. The present invention provides a supporting element and drive assembly having a controller adapted to selectively position the supporting element according to a predetermined sequence. The present invention provides a drive assembly having a controller that periodically and repeatedly displaces the supporting element. The present invention provides a method for adjusting the position of a supporting element in a seat in the manner described above.

The present invention provides a supporting element within a vehicle seat that includes a controller for automatically adjusting the position of the supporting element according to a predetermined cycle. More particularly, the apparatus of the present invention is adapted for stimulating the muscles of the seat occupant and includes a flexible supporting element adapted to be coupled to a seat for movement relative thereto. A driver automatically and repeatedly moves the flexible supporting element through an adjustment cycle that includes a movement in a first direction to a set position followed by a movement in a second direction to another set position. Each movement is continuous in time, and separated by a pause before direction changes.

The method of the present invention relieves muscle fatigue in a seat occupant by adjusting the curvature of the supporting element and generally includes the step of placing a supporting element in a first position operatively engaging a muscle of the seat occupant wherein the first position defines a first degree of curvature of the supporting element. The method includes the additional steps of automatically adjusting the curvature of the supporting element according to an adjustment cycle that includes starting at the first degree of curvature, increasing or decreasing the degree of curvature a first amount to define a second degree of curvature, reversing movement direction from the second degree of curvature, and increasing or decreasing the degree of curvature of the supporting element a second amount to define a third degree of curvature.

A method and data structure are disclosed and claimed for a control system to achieve the cyclic motion pattern. These may be applied to other types of ergonomic supports, such as inflatable bladders, push paddles and flexible wire mat supports.

Further features and advantages of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a supporting element and positioning assembly according to the present invention.

FIG. 2 is a side view of the supporting element shown in Fig. 1.

FIG. 3 is a schematic illustration of a positioning assembly control module according to the present invention.

FIG. 4 is a schematic illustration of the position assembly control module according to another embodiment of the present invention.

FIG. 5 is a flow chart of the control system and data structure of the present invention.

DETAILED DESCRIPTION

The present invention relates to an apparatus and method for adjusting the position of a supporting element in a seat according to a predetermined sequence. In general, the adjustment of the supporting element is controlled by a module that conveys an electric current to an electric motor in a predetermined cycle to automatically and cyclically adjust the position of the supporting element. The periodic adjustment provided by the present invention operates to reduce the muscle fatigue that generally occurs during extended stationary periods in a seat and increases comfort. Additionally, the present invention may impart a desirable massage effect.

The following description of the present invention is merely exemplary in nature and is not intended to limit the scope of the claimed invention. Moreover, while the invention is depicted for use in the lumbar region of a seat, the description is intended to adequately teach

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one skilled in the art to make and use the apparatus and method described and claimed herein in a variety of environments. The depicted alternative is a lumbar support of the traction driven, arching support element type.

As illustrated in FIG. 1 of the drawings, a lumbar support 10 is shown to include a flexible elastic supporting element having a body 14 interconnecting an upper portion 16 and a lower portion 18. A positioning assembly 20 is coupled to supporting element 12 to selectively displace upper portion 16 relative to lower portion 18 thereby bowing body 14 such as is illustrated in FIG. 2. In the preferred embodiment, positioning assembly 20 includes an electric motor 22 coupled to drive an actuating assembly 24 that includes a cable 25 coupled to upper and lower portions 16 and 18 of supporting element 12 such as by attachment fitting 26 and 28, respectively. While the embodiment of the present invention described herein is specifically adapted for use with the two-way or four-way electric lumbar supports manufactured by Schukra of North America Ltd. having a place of business in Windsor, Ontario, those skilled in the art will appreciate that a variety of supporting elements and actuating apparatuses may be used with the present invention without departing from the proper scope of the appended claims. For example, the supporting element may include an inflatable membrane coupled to a pressure regulator, a push paddle, a levered panel or a flexible wire mat.

Supporting element 12 is illustrated in FIG. 2 to be positionable in a variety of degrees of curvature of body 14 each defining an apex 27. As described below, apex 27 is displaceable in a first direction indicated by arrow 30 toward the seat occupant and in a second direction away from the seat occupant and opposite arrow 30 by selectively increasing and decreasing, the curvature of body 14.

FIG. 3 schematically illustrates an embodiment of the present invention wherein positioning assembly 20 is adapted to change the curvature of supporting element 12 according to a predetermined adjustment cycle. In this embodiment, positioning assembly 20 interconnects supporting element 12 and a power source 32. As shown, positioning assembly 20 includes a coupling 34, such as the previously described actuating assembly 24, mechanically connecting motor 22 to supporting element 12 and a control module 36 electrically connecting motor 22 to power source 32. As is explained in greater detail hereinafter, module 36 is adapted to control current to motor 22 in order to selectively drive motor 22 and displace supporting element 12 according to the predetermined adjustment cycle. Module 36 embodies the data structure and control system of the present invention. The following description of the components and operation of module 36 provides a general illustration of the function and operation of the module. However, those skilled in the art will appreciate that a variety of equivalent components known in the art may be substituted for those described below and/or the interrelationship between the components may be modified such that module 36 communicates the same or an equivalent current cycling control of the motor 22.

With continued reference to FIG. 3, an embodiment of controller module 36 is shown to include an activator 38, current regulator 40, and polarity switch 42 disposed between power source 32 and motor 22. Activator 38 is illustrated as a switch positionable between an open position preventing the flow of an electric current from power source 32 to current regulator 40 and a closed position wherein an electric current is communicated to current regulator 40. In the preferred embodiment, activator 38 communicates with an input 39 (FIG. 4) with which a

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seat occupant can selectively initiate and terminate the performance of the predetermined adjustment cycle.

Cycling begins at a first position of the supporting element selected by a seat occupant by using a separate control such as an electrical switch or mechanical lever. Cycling oscillates between a second position and third position each of which are equidistant from the first position. One of the second and third positions is forward of the first position and the other is rearward of the firs position. Preferrably, the second position is six millimeters from the first position, and the third position is six millimeters from the first position in the opposite direction, for a total range of travel of 12 millimeters. Ergonomic studies have revealed that this configuration is preferred by surveyed seat occupants. Accordingly, the movement pattern embodied in the data structure and control system of the present invention is understood to represent an optimization of combining the insensate action of passive movement of paraspinal muscles and the spine with the sensation of a massaging action enjoyed by surveyed seat occupants. Other ranges of motion are considered to be within the scope of the present invention, including ranges small enough to be imperceptible to a seat occupant, and ranges large enough to be felt as desirable massaging actions.

In the preferred embodiment, input 39 includes a lumbar switch (not shown) coupled to the exterior surface of the seat. The lumbar switch may be manipulated by the seat occupant to adjust the position of the lumbar support by changing the curvature of supporting element 12. In a manner known in the art, input 39 and activator 38 are configured such that rapid actuation of the lumbar switch initiates the adjustment cycle provided by current regulator 40 by closing activator 38 as described above. Those skilled in the art will appreciate that a variety of equivalent activating structures such as, for example, a momentary switch may be

used without departing from the scope of the present invention as defined by the appended claims.

Current regulator 40 functions to selectively communicate an electric current to polarity switch 42 such as by a timing circuit. While activator 38 is in its closed position, current regulator 40 prevents the flow of an electric current to polarity switch 42 during a first time interval and communicates a current to switch 42 during a second time interval. The transition between forward and rearward movements is controlled by polarity switch 42 and switch controller 68.

Polarity switch 42 is of a type generally known in the art and is adapted to selectively reverse the polarity of the electric connection between module 36 and motor 22 so as to cycle the movement of motor 22 in first and second directions. As schematically illustrated in another embodiment of controller module 36 shown in FIG. 4, polarity switch 42 communicates with a switch controller, 78. Switch controller 78 selectively moves polarity switch 42 from and to a first position defining a first polarity connection between module 36 and motor 22 and moves polarity switch 42 to and from a second position defining a second polarity connection. As generally described above, the current regulator 40 communicates to motor 22 through the first polarity connection to define the first movement in the first direction. Similarly, the second polarity connection communicates the second movement in the second direction to motor 22. Motor 22 is coupled to module 36 such that current controlled by the system of the present invention drives motor 22 in a first direction and, through mechanical coupling 34, moves supporting element 12 in the direction indicated by arrow 30. Periodically thereafter, the system of the present invention embodied in module 36 causes motor 22 to move apex 27 of supporting element 12 in the direction opposite arrow 30.

It should be appreciated that a variety of electro-mechanical or software implemented polarity switches known in the art may be used with the present invention without departing from the proper scope of the appended claims.

Current regulator 40 is configured to communicate an electric current to polarity switch 42 while the support element 12 moves through a range of positions, to prevent the flow of current during time intervals between movements. The duration of each movement ranges from about 5 seconds to about 25 seconds. The preferred time intervals or pauses are about three (3) seconds.

Those skilled in the art will appreciate that the specific curvature adjustment is dependent upon several variables including the specific configuration of motor 22, the firmness of the supporting element, the amount of padding between the supporting element and the seat occupant, and the load that the seat occupant exerts on the supporting element. With these variables in mind, the preferred curvature adjustment magnitude for the supporting element is one that is sufficient to stimulate the seat occupant's muscles proximate to the supporting element or slightly modify the posture of the seat occupant. A first magnitude of curvature is selected by the passenger with separate controls. The speed of movement is also dependent in application on the variables discussed above.

It should be appreciated that it is possible to specifically control not only the magnitude and frequency of each supporting element curvature adjustment but also the full range of travel of supporting element 12 that is provided by module 36. More particularly, while again being dependent upon variables such as the firmness of the supporting element and the amount of padding between the supporting element and the seat occupant, the full range of apex travel in known lumbar supports is up to fifty (50) millimeters.

It is specifically preferred that the magnitude of each movement of apex 27, be within the range of about twelve (12) millimeters. This periodic movement of the occupant's muscles and spine is generally sufficient to increase circulation and decrease muscle fatigue that generally occurs during periods of sitting.

Switch controller 68 (FIG. 3) is adapted to change the position of switch 42 at predetermined displacement magnitudes or time periods thereby reversing the polarity of the connection between module 36 and motor 22. For example, it is preferred that module 36 includes end stops (not shown) defining the maximum and minimum curvature displacement provided by the adjustment cycle. Among the many options familiar to the art, end stops may include mechanical stops preventing movement of the motor or actuator beyond the maximum or minimum values, software implemented stops of a similar nature, or a counter for limiting the time period for generating current through a particular polarity. Of course, other equivalent timing or measurement apparatuses may be used without departing from the scope of the invention as defined by the appended claims. The preferred end stop configuration is described more fully below.

Those skilled in the art will appreciate that activator 38 is adapted to remain in the closed position allowing current regulator 40 and polarity switch 42 to continually generate and communicate current to motor 22 until the operator cancels the adjustment cycle. It is contemplated that cancellation may occur through manual or automatic intervention. For example, in the preferred embodiment, manual actuation of the lumbar switch via input 39 operates to open activator 38 thereby terminating the adjustment cycle. Similarly, the adjustment cycle may be cancelled after a fixed time period, for example ten minutes, when the vehicle ignition is turned off, or any other manner known in the art. Readjusting the initial,

central, first curvature position of the support element also stops the cycling movements. It should be appreciated that the adjustment cycle may be reinitiated at any time by the seat occupant such as through input 39 in the manner previously described.

In addition to the automated supporting element adjustment feature, the embodiment of controller module 36 shown in FIG. 4 includes a position indicator 74 communicating with motor 22 and a memory 76. In a manner generally known in the art, position indicator 74 is adapted to record the position of motor 22, actuator 24, or support element 12 in a register of memory 76 upon initiation of the adjustment cycle through activator 38 and input 39. In this embodiment, module 36 includes a controller 78 adapted to retrieve the initial position from memory 76 and return motor 22, actuator 24, or supporting element 12 to the initial position upon cancellation of the adjustment cycle. Accordingly, controller 78 is shown to communicate with power source 32, polarity switch 42, and memory 76 such that controller 78 may selectively position polarity switch 42 and communicate an electric current of an appropriate duration to return the motor 22 or other element to the initial position. Those skilled in the art will appreciate that a variety of position indicating structures known in the art may be used with the present invention, such as, for example, a transducer, without departing from the scope of the appended claims.

As described above, the present invention provides an apparatus and method for adjusting the position of a supporting element within a seat according to a predetermined cycle in order to relieve muscle fatigue of the seat occupant. The repeated movement of the supporting element creates a pumping action that increases blood circulation through the muscle fibers and prevents lactic acid build-up within the muscles. Passive motion of spine and muscles reduces or eliminates muscle fatigue that generally occurs during long periods of

sitting. While the preferred timing of the supporting element adjustments described and claimed herein have been found to be particularly suitable for relieving muscle fatigue in the present apparatus and method, those skilled in the art will appreciate that other time intervals and adjustment magnitudes may be used without departing from the proper scope of the present invention as defined by the appended claims.

Figure 5 is a flow chart of the control system of the present invention, as embodied in controller module 36, current regulator 40 and controller 78. The data structure represented by Figure 5 is stored in a machine readable format, preferably a transistor configured integrated chip and most preferably a MC68HC705B16, which is a Motorola 8-bit micro-controller.

Establishing steps 80 and 82 are executed manually by a seat occupant. The passenger adjusts, 80, the position of the supporting element 12 to a desired, comfortable position, which becomes the first position of the cycle. The first position is also the center of the cycle range, except in cases where the range would extend beyond the mechanical limits of the supporting element, which is managed by the control system in a manner more fully set out below. If the position is not comfortable, the passenger re-adjusts it, 82. This final setting before cycling initiates the control system to establish the relative positions at which inward movement will stop and outward movement begin and visa versa, which position information is monitored by position sensor 74. Position sensing is a well known art and various sensors which may be placed in various places on the unit are known, and known to be equivalent alternatives.

After the desired first position is set, the passenger presses a separate button to initiate cycling, 84. The control system signals the motor to begin a first movement, 86, in a first direction, which is inwards in figure 5. Equivalently, the first movement could be outwards. The control system monitors the position of the support element 12 by checking the position

sensor 74. When a check of the position sensor first indicates that a second, innermost position six millimeters from the first position has been reached, 88, the next step of the control system, 90 is executed. Before that second position is reached, current flow to the motor 22 is maintained according to step 86 so that the support element keeps moving. The second position is known from step 82, where the first position was selected, initializing a position representation in a memory register of the control system for all three relevant positions.

Upon reaching the innermost (or alternatively, outermost) second position six millimeters from the first position motion is stopped, 88. A timer is initiated to wait three seconds, 90. This pause to maintain a set curvature of spine and muscles corresponds to ergonomic study results indicating the desired and beneficial cycle parameters.

At the end of the three second pause, the polarity switch 42 is reversed and current re-initiated to motor 22 in order to start a second movement in a second direction, 92. Again the position sensor monitors the movement of the support element 12 to determine if the position of it has yet matched the third position which was initialized in step 82. The control system continues current to the motor 22 in the second direction until the support element 12 has moved 12 millimeters in that direction, 94. When 12 millimeters has been traveled and the third position reached, current is again interrupted and the timer again engaged to pause movement.

When the second pause is finished, the polarity switch 42 is again reversed, current flow again re-initiated with the reversed polarity and another movement in the first direction begun, 98. Since this movement begins at the third position, which is at the full extent of the preconfigured cycle range, instead of beginning at the first, central position, the third

movement in the first direction must go 12 millimeters to reach the second position, which is at the other full extent of the preconfigured cycle. Accordingly, the control system has the third monitoring loop, 100, for monitoring the continuing 12 millimeter back and forth movements. Only the first movement is 6 millimeters. An option not depicted in Figure 5 is a final 6 millimeter move to return the support element 12 to the original, first position after cycling stops.

Cycling is stopped by any one of at least three events. One is the passenger readjusting the first initial position again, as she did at step 80. Using that control during cycling stops the cycling, 104, and re-initiates the control system memory register with new first, second and third position values. Turning off the automobile also stops cycling.

Finally, the cycle is preconfigured to automatically stop after ten minutes. The control system checks a timer at 102. If ten minutes is not up, the cycle is continued at step 90 so that 12 millimeter moves continue. If ten minutes has been reached, the control system stops the cycle.

It is considered to be within the scope of the present invention that it may be used to control cycling movement of any type of ergonomic support for automobile seats, furniture and the like. The depicted alternative embodiment is an automobile seat using a lumbar support of the traction actuated, arching support element type depicted in Figures 1 and 2. It is considered to be within the scope of the present invention that it may be used to control cycling movement of any type of lumbar support, including push paddles, flexing wire mats, bladders and the like.

The traction actuated, arching support element type of the depicted alternative embodiment typically has a total, mechanical range of about 40-50 millimeters. If, for

example, a lumbar support with a 50 millimeter range is used, the passenger can set the first position anywhere from 6 millimeters to 44 millimeters and cycling will proceed as described above. In the following manner, the control system of the present invention can also cycle through a truncated range in the case of a first position setting between zero and six millimeters and 44 and 50 millimeters, where the normal cycle range would be interrupted by the mechanical limits of the support element 12.

Stall sensors, 70, and their installation and use are known to those of skill in the art. Generally, they are simple ampmeters set to send a signal when a motor's amperage exceeds a preconfigured limit, as in the case of a motor mechanically prevented from further turning, as would be the case at the ends of the total range of the depicted lumbar support. Other types of stall sensors or position sensors indicating the ends of the total range of the depicted lumbar support could be used within the scope of the present invention, such as, for example, software implemented end stops.

In the preferred end stop configuration, switch controller 68 includes a stall sensor 70 configured to detect the stalling of motor 22 upon reaching one of the respective mechanical end stops. In the preferred embodiment, stall sensor 70 is a current meter communicating with polarity switch 42 and adapted to actuate switch 42 when the measured current exceeds a predetermined value. It is contemplated that the specifications of motor 22 provide for a running current between 0.7 and 3.0 amperes with an optimal running current of 1.25 amps. In this configuration the stall current of motor 22 is 6.5 to 7.0 amperes. The full travel of the motor 22, actuator 24, or supporting element 12 to their mechanical limits is used as the end stops.

The control system of the present invention incorporates stall sensor feedback at steps 106, 108 and 110. When the mechanical end of the support element 12 range stalls the motor 22, current is stopped and movement in that direction is curtailed. As indicated in figure 5, when this happens, the three second pause step is immediately begun, and cycling continues from there with a succeeding movement in the opposite direction. This may happen on every cycle when the movement proceeds to a stall, resulting in a continuing cycle that is truncated by the end of the support element range. Travel in the opposite direction would continue to the full extent of the six millimeters from the first position. For example, if the first position was selected at 48 millimeters on a 50 millimeter range lumbar support, inward movement would proceed normally to the 42 millimeter position, but outward movement would be limited to two millimeters by the stall turn at the 50 millimeter limit. The total cycle range would be eight millimeters.

The passenger can set only the first position of the support element, 12. While the order of movements, range of movement, duration of the cycling and length or existence of pauses may not be altered by the passenger in the depicted alternative embodiment, other embodiments wherein the passenger can control these parameters are considered to be within the scope of the present invention. Likewise, alternate preconfigurations of these parameters by the manufacturer, assembler or ultimate seller of the device or seats incorporating it are also considered to be within the scope of the present invention.

In view of the foregoing, it will be seen that the several advantages of the invention are achieved and attained.

The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best

utilize the invention and various embodiments and with various modifications as are suited to the particular use contemplated.

As various modifications could be made in the constructions and method herein described and illustrated without departing from the scope of the invention, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative rather than limiting. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims appended hereto and their equivalents.